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Technology Infrastructures

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SUMMARY

A strong industry is of key importance for Europe's prosperity.

One of the main barriers for industrial transformation is the lack of scale-up and technology diffusion. Considering the revolutionary technological developments, industry and notably SMEs require access to the right technology infrastructures to quickly develop and test their innovations and successfully enter the market. Technology infrastructures are understood as

facilities, equipment, capabilities and support services required to develop, test and upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public or private status. Their users are mainly industrial players, including SMEs, which seek support to develop and integrate innovative technologies towards commercialisation of new products, processes and services, whilst ensuring feasibility and regulatory compliance.

Examples of technology infrastructures range from facilities to develop electrolyser stacks to biogas plants, clean-room facilities for chip production to test areas for automated shipping or road traffic safety solutions, from wind tunnels to testbeds for multi-functional nano-composites, multi-material 3D printing, to thermo-plastics and industrial robotics.

Technology infrastructures require high investment both in the set-up and in the keeping up with the state-of-the-art. Most technology infrastructures rely upon a mix of private and public (national and EU) funding. Under Horizon 2020, the EU has invested some EUR 1.2 billion in relevant projects while the European Regional Development Fund is providing in the 2014-2020 programmes around EUR 16 billion for building or upgrading research and innovation infrastructures, including many technology infrastructures, and around EUR 21 billion for R&I support services that foster the exploitation and development of technologies, in particular by SMEs. These investments focus on the priorities identified in the Smart Specialisation Strategies at national or regional level.

Technology infrastructures are supported by a mix of regional, national and European initiatives. Each player of the technology infrastructure system has developed according to historical conditions and needs, leading to a wide diversity of cases, sizes, structures, and practices, which also reflect the rich diversity of Europe. The rationale for all these policy initiatives is that with rising technological complexity industry's competitiveness and ability to succeed on global markets critically depends on possibilities to test, validate and upscale new technological solutions. Policy initiatives and financial support to technology infrastructures are a global phenomenon. Three quarters of funding agencies in 101 countries economies accounting for more than 90 per cent of global GDP have specific schemes to upgrade breakthrough technology in industry.

The stocktaking of the EU's current technology infrastructure landscape shows that there are large regional differences in terms of the availability of technology infrastructure support, fragmentation, risk of duplication of activities, transnational accessibility difficulties as well as a lack of mechanisms to identify industry needs or missing infrastructure capacity. The key four challenges identified are about prioritisation of technology infrastructures, their visibility and accessibility as well as their networking.

The present analysis suggests that there is a critical momentum for the EU together with Member States to be more ambitious, exploring with relevant national and regional stakeholders a shared vision and jointly developing a European strategy for technology infrastructures to support industry scale-up and technology diffusion across Europe.

This document draws on the findings of an analysis by the Commission of the EU investments made through various funding programmes. The analysis was carried out in cooperation with Members States, policymakers, and relevant stakeholders, notably users and providers of technology infrastructures.

ACRONYMS GLOSSARY

Artificial intelligence	AI
Artificial Intelligence Exploration program	AIE program
Cross-Agency Priority Goal	CAP
Defence Advanced Research Projects Agency	DARPA
Digital, Internet, Materials & Engineering Co-creation	DIMECC
Digital Innovation Hubs	(DIHs)
European Association of Research and Technology Organisations	EARTO
European Commission	EC
European Factories of the Future Research Associations	EFFRA
European Framework programme for research and Innovation	Horizon 2020
European Institute of Technology	EIT
European Pilot Production Network	EPPN
European Regional Development Fund	ERDF
Enterprise Resource Planning	ERP
European Technology Transfer Offices circle	TTO CIRCLE
European Union	EU
Factories of the Future	FoF
Fraunhofer-Gesellschaft	Fraunhofer
French Alternative Energies and Atomic Energy Commission	CEA
Federal Ministry of Education and Research — Germany	BMBF
Gross Domestic Product	GDP
High Performance -Computing	HPC
Intellectual Property Rights	IPRs
Joint Research Centre	JRC
Key Enabling Technologies	KETs
KETs Technology Centres	KETs TCs
Knowledge and Innovation Communities	KICs
Made in China 2025	MIC
Ministry of Industry and Information Technology	MIIT
Open Innovation Test Beds	OITBs
Research and Development	R&D
Research and Technology Organisations	RTOs

Research Fab for Micro-electronics	FMD
Research Institutes of Sweden	RISE
Small and Medium Enterprise	SMEs
Smart Industry strategy	SIS
Staff Working Document	SWD
Strategic Transport Research and Innovation (roadmaps)	STRIA roadmaps
Sweden's Innovation Agency	VINNOVA
United States	US
United Nations Conference on Trade and Development	UNCTD
Manufacturing Extension Partnership	MEP
Mechatronics Prototyping Facility	ProM
Technology readiness levels	TRLs

1. INTRODUCTION

Technology is becoming increasingly complex while technology cycles grow ever shorter and technology-based innovation requires substantially high capital investment. The growing complexity and interdisciplinary nature of technology makes it more difficult for industry to capture fully its innovation potential, which also requires an important understanding of non-technological aspects. To develop and test their demonstrators and prototypes, European industry, and in particular small and medium-sized enterprises (SMEs), need access to state-of-the-art and interdisciplinary technology infrastructures, which they cannot afford on their own.

A strong industry is of key importance for Europe's economic prosperity and competitiveness, and it continues to be the major driver of productivity, growth, innovation and employment in Europe. As highlighted in the Council conclusions of November 2017[1] and March 2018[2], **the competitiveness of the EU economy depends directly on its ability to continuously adapt and innovate by investing in new technologies**, digitalising its industrial base and transitioning to a sustainable low-carbon and circular economy.

In 2017, the Commission adopted the Communications "*Investing in a smart, innovative and sustainable Industry-A renewed EU Industrial Policy Strategy*[1]" and "*Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth*[2]". In 2018, this was followed by the adoption of the Communication '*A renewed European agenda for research and innovation – Europe's chance to shape its future*[3]'. In these Communications **the lack of scale-up and technology diffusion** are identified as the **main barriers to industrial transformation in the EU,** with innovations not systematically translated into new markets and growth opportunities, **due to insufficient investment in infrastructures and new technologies.**

The Commission proposal for the next Research and Innovation Framework Programme – Horizon Europe — supports a strong engagement of all players in co-designing and co-creating research and innovation agendas, particularly in pillar two 'Global Challenges and Industry.' Horizon Europe will also support an EU innovation ecosystem of technology infrastructures that will cover all key enabling technologies necessary to enable commercialisation of European innovations[4]. Synergies are sought with the proposals for the Digital Europe programme which will support a substantial reinforcement of competence centres in digital technologies and the European Regional Development Fund (ERDF)[5]. Given the impact expected from the investments under these three initiatives (Horizon Europe, Digital Europe and ERDF), it is worth reflecting on how best to coordinate a common strategic approach to technology infrastructures. This staff working document therefore aims to give an evidence base for such a reflection and to prepare a possible EU strategy with stakeholders regarding investment in technology infrastructures and facilitating access to them.

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[1] COM/2017/0479 final *Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy*: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0479

[2] COM(2017) 376 final, *Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth*: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0376

[3] COM(2018) 306 final, *A renewed European Agenda for Research and Innovation - Europe's chance to shape its future*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0306

[4] COM(2018) 436 final, *Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on establishing the specific programme implementing Horizon Europe – the Framework Programme for Research and Innovation* Annexes 1 to 3, page 33 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0436

[5] ERDF will shift the focus of its innovation investments towards the up-take of advanced technologies, based on revisited Smart Specialisation Strategies with a fresh focus on smart economic transformation addressing digitalisation, decarbonisation, internationalisation, skills and the industrial transition of SMEs. See: Proposals for the Common Provisions Regulation, and other Cohesion Policy regulations: https://ec.europa.eu/commission/publications/regional-development-and-cohesion_en

1.1. Technology infrastructures

The term ‘technology infrastructures’ can be understood as a broad concept currently encountered under many activities in various sectors across different EU programmes, e.g. pilot lines, testing facilities, digital innovation hubs, open innovation testbeds, KETs centres, demonstration sites or living labs.

For the purpose of this document, technology infrastructures are defined as follows:

Technology infrastructures are facilities, equipment, capabilities and support services required to develop, test and upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public or private status. Their users are mainly industrial players, including SMEs, which seek support to develop and integrate innovative technologies towards commercialisation of new products, processes and services, whilst ensuring feasibility and regulatory compliance.

Technology infrastructures are critical for the development of new technology-based innovative products, and services. They help businesses to reduce risk when testing the technological feasibility of new ideas, shorten time-to-market by providing pointers for streamlining and scaling up internal operations, avoid expenditures for new equipment and/or avoid disruption of business operations. They facilitate exposure to outside expertise, enable greater scrutiny of growth opportunities in novel product and service offers and provide impulses for standards compliance and development of new testing/certification standards.

Technology infrastructures can be sector-specific or technology-focused and can be public, semi-public or private. They may be operated by not-for-profit research and technology organisations (RTOs) or technical universities but can be found in big industries as well. Technology infrastructures can also be shared, i.e. operated by several organisations, not only to be more cost effective but also to reduce investments, and share expertise and staff. Access and services may be provided to local customers or to a diversified set of customers at national, European and world level.

The focus of technology infrastructures differs from that of research infrastructures[6], which include major scientific equipment, archives and scientific data, e-infrastructures and communication networks. Research infrastructures focus on lower technology readiness levels (TRLs), their users are researchers primarily from public bodies such as universities and research organisations and they are predominantly sustained through public support. Technology infrastructures, at higher TRLs, are industry- (including SME-) focused and therefore complementary to research infrastructures. This does not, however, preclude researchers and academics who are seeking to develop technologies beyond lab-based concept levels from accessing technology infrastructures, just as SMEs can access research infrastructures to test early-stage ideas.

[6] a) http://ec.europa.eu/research/infrastructures/index.cfm?pg=about b) ‘research infrastructure’ means facilities, resources and related services that are used by the scientific community to conduct research in their respective fields and covers scientific equipment or sets of instruments, knowledge-based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research. Such infrastructures may be ‘single-sited’ or ‘distributed’ (an organised network of resources)

1.2. Economic considerations of investing in technology development

Fast and comprehensive changes in science and technology are transforming our economy, generating new markets and players. Key Enabling Technologies (KETs)[7] are fundamental to many of these emerging innovations and account for a significant number of jobs and production in the EU.

For instance, in 2013 (the most recent year for which data are available), KETs-based products represented 19 % of total EU-28 production (EUR 950 billion), compared with 16 % in 2003. KETs were associated with 3.3 million jobs, with the biggest share being in advanced manufacturing technology and micro and nanoelectronics[8]. KETs offer considerable economic value as they are present in nearly all intermediate technological products and form the constituent parts of innovations further along the chain of development.

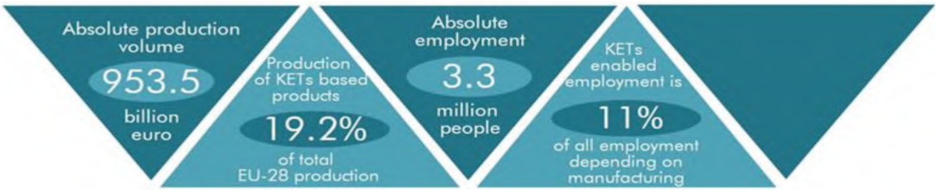

Figure 1: Value created by the deployment of KETs in industry

Between 2007 and 2015, EU KETs-related exports grew, with the exception of micro/nanoelectronics, which faced increasing competition from the US and Asia. Available data for 2010 and 2015 suggest that while Europe increased its KETs-related exports, East Asia[9] registered a considerably higher increase, with China's performance being particularly strong. Since 2015, the EU-28 has outperformed North America[10] by approximately 30 % in shares of total exports for technology generation and exploitation (Figure 2).

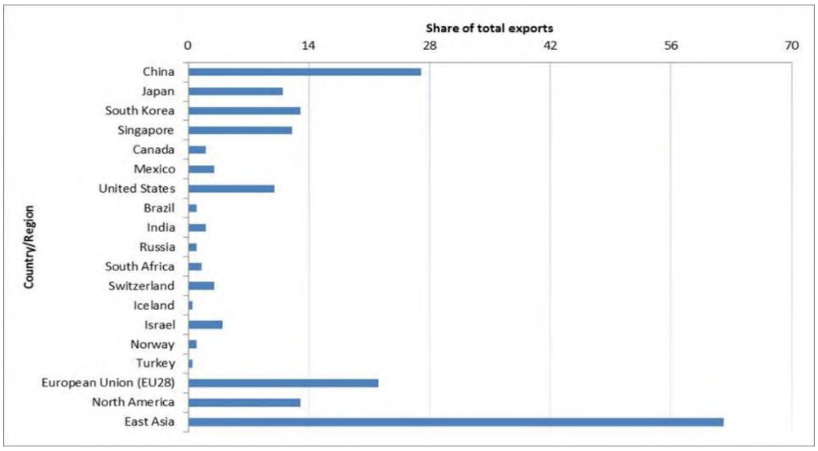

Figure 2: Technology generation and exploitation, share of total exports. Comparison by countries/regions for all KETs in 2015[11]

[7] During the period 2014-2020, KETs have been defined as micro and nanoelectronics, nanotechnologies, industrial biotechnology, advanced materials, photonics and advanced manufacturing technologies. Economic studies on KETs conducted during this period therefore refer to these six technologies.

[8] a) Report Re-finding industry (2018): https://publications.europa.eu/en/publication-detail/-/publication/28e1c485-476a-11e8-be1d-01aa75ed71a1. b) For instance, by the end of 2015 the EU photonics industry employed 290 000 people, compared to 235 000 people in 2005 (+23 %). 42 000 new jobs could be created in photonics by 2020. European photonics production has grown by 5 % a year on average since 2005 and the European photonics market is estimated at EUR 69 billion.

[9] Japan, China, South Korea, Singapore and India)

[10] US, Canada and Mexico

[11] KETs Observatory (2017)

However, this status risks being undermined by a lack of investment in validating, demonstrating and disseminating technology for the commercialisation of products, processes or services. In fact, while the EU runs an overall trade surplus for manufactured goods[12], a closer look at exports of high-tech products and KETs-based products reveals a deficit for these sectors. In 2015, the EU showed an overall deficit of EUR 63.5 billion in trade in high-tech products with the group of 20 leading trade partners. The largest deficit for high-tech products was with China. Among the top 20 partners, the EU had a trade deficit in the high-tech sector with eight other countries: Vietnam, Malaysia, the United States, Thailand, Switzerland, South Korea, Japan, and Singapore.

For SMEs, and in particular those specialised in manufacturing, the impact of being able to access technology infrastructures can be significant. A recent report on the impact of companies interacting with the German RTO Fraunhofer showed that, one year after this interaction, these companies experienced a 9 % increase in sales and a 7 % increase in employment. It further showed that sales shifted towards more innovative products[13]. In a different model, the members that belong to the Institutes of the Manufacturing USA programme (typically SMEs) benefit from cost-sharing agreements to distribute the costs and the risks associated with pre-competitive R&D projects. Though members pay a membership fee, the impact of being able to access shared facilities as well as the full breadth of an Institute's project outcomes results in a 5 times leveraged return on spending, even if members are not involved in every project[14].

2. EXISTING TECHNOLOGY INFRASTRUCTURE INITIATIVES

Supporting investments in technology infrastructures is a prominent part of regional and national industrial innovation strategies.

The objective of this section is to provide examples of how existing initiatives contribute to breakthrough innovations, reinforce collaboration between different value chains and actors, and foster the development of the industrial base through the creation of spin-off companies.

Regional governments and funding bodies play an important role in supporting innovative ecosystems through co-investment and different types of collaboration with technology infrastructures. They support cluster organisations and develop interactions among the regional innovation players (e.g. among enterprises, research organisations, educational institutions, support and advisory bodies and civil society in the entrepreneurial discovery processes to identify and invest in smart specialisation priorities).

2.1. Regional initiatives

The European Regional Development Fund (ERDF) plays an important role in supporting the construction of research and innovation infrastructures and their delivery of services to businesses. In the current ERDF operational programmes, around EUR 16 billion are earmarked for building or upgrading research and innovation infrastructures, including many technology infrastructures. Around EUR 21 billion in ERDF funding are targeted at R&I support services that foster the exploitation and development of technologies, in particular by SMEs. Such support services can take the form of voucher schemes[15], SME-research cooperation support, technology transfer and advisory services.

[12] EUR 224 billion between January and October 2017
[13] "Do Companies Benefit from Public Research Organisations? The Impact of Fraunhofer" 2018; https://www.fraunhofer.de/content/dam/zv/de/leistungsangebot/wirkung-von-forschung/the-impact-of-fraunhofer.pdf
[14] "Manufacturing USA: A Third-Party Evaluation of Program Design and Progress" January 2017 https://www2.deloitte.com/us/en/pages/manufacturing/articles/manufacturing-usa-program-assessment.html
[15] The ICT Innovation Vouchers scheme aims to boost business innovation and increase competitiveness for micro-enterprises and SMEs, by investing in innovative digital business solutions.

Example: *Tecnalia's Harsh Lab*[16] *is an advanced floating platform anchored to the sea floor 1 mile off the coast from Armintza (Basque Country, Spain). It is designed for assessing materials and components against corrosion, ageing and fouling phenomena in a real offshore environment. Harsh Lab focuses on extending the life cycle of components and equipment in harsh environments and enables standardised probes and components to be evaluated in both splash and immersion zones. This offshore laboratory can handle up to 125 samples in atmospheric zone and 600 in splash/immersion. HarshLab's development has been supported by the Basque government and the European Union through the Basque country's ERDF operational programme for 2014-2020.*

Example: *Mechatronics Prototyping Facility (ProM Facility)*[17] *is a new infrastructure in the Region of Trentino (Italy), which provides companies operating in the mechatronics sector with an integrated platform for the prototyping and qualification of mechatronic systems and subsystems. The facility has innovative machines for the rapid prototyping and three-dimensional printing of artefacts, including 3D metallic and polymer printing, and the laser cutting of tubes and sheet metal. The facility also has advanced metrology systems such as x-ray tomography and high-speed digital image scanners. The infrastructures benefited from an investment of EUR 6 million in ERDF funding. ProM is located in Polo Meccatronica, one of the six Business Incubator Centres of Trentino Sviluppo, which hosts 116 companies, employs 720 people and generates a turnover of EUR 415 million.*

Example*: The Pharmapolis Pharmaceutical Science Park*[18] *is a 10 500 m² science park from Debrecen (Hungary), who targets SMEs in the pharmaceutical research industry which rather than contributing to continued development of existing products, want to harness R&D&I in order to create new products, services and technologies. The facility created 120 jobs for researchers, as well as the contributed to the development of local industry and business, and the city of Debrecen as a whole. The infrastructure benefited from an investment of EUR 7.7 million in ERDF funding.*

Example: *Białystok University of Technology*[19] *in Poland has developed laboratory infrastructure for research into renewable energy. This has led to identification of methods for improving renewable energy efficiency, which are suitable for use in the wider economy. An experimental biogas plant and oil pressing and refining machinery were also developed. This has resulted in the development of highly efficient renewable energy production solutions and in an environmentally friendly technology, which meets the needs of the regional economy. The ERDF investment has reached EUR 2.8 million.*

Example: *IT4Innovations supercomputing centre*[20] *in the Moravian-Silesian Region in Czech-Republic provides high-performance computing and data analysis for scientists and industry. This includes systems that can enhance industrial design, advance medical technology and predict natural hazards. Since its establishment, 580 researchers have been supported in over 260 projects. One in seven of these projects are collaborations with industry. In addition, it has helped to create over 260 new highly-skilled jobs. The investments amounts to EUR 77 million, out of which EUR 46 million are EU investment.*

At the same time, there are very successful technology infrastructures funded by regional and private sources. IMEC's new 4000 m^2 cleanroom facility in Leuven (Flanders, Belgium) for the development and production of ultra-small chips, for instance, represents a total investment of more than EUR 1 billion of which EUR 100 million came from the Flemish government and over EUR 900 million from more than 90 leading industry partners[21]. Similarly, the Clinatec healthcare platform (Grenoble,

[16] https://www.tecnalia.com/es/energia-medioambiente/infraestructuras-y-equipamiento/harsh-lab-v10/harsh-lab-v10.htm
[17] https://www.promfacility.eu/en/tech.html
[18] https://ec.europa.eu/regional_policy/en/projects/hungary/pharmaceutical-research-development-and-innovation-centre-provides-tailor-made-technological-services
[19] http://ec.europa.eu/regional_policy/en/projects/poland/new-renewable-energy-research-infrastructure-at-biaystok-poland
[20] http://ec.europa.eu/regional_policy/en/projects/czech-republic/it4innovations-supercomputing-centre-boosts-industry-and-research
[21] https://www.imec-int.com/en/articles/imec-opens-new-cleanroom-serving-the-global-semiconductor-industry-in-its-search-towards-the-ultimate-ic-technology

France) – managed by CEA, the Grenoble University Medical Centre and the Université Grenoble Alps – received most of its initial EUR 20 million investment from local governments in the Auvergne-Rhone-Alps region, with another EUR 5 million provided through public funds, ERDF support and charitable donations. Clinatec uses a multidisciplinary approach to drive innovation in micro and nanosystems for healthcare, speeding up proof-of-concept testing and transferring new medical technologies to manufacturers[22].

2.2. National initiatives

Probably the most encompassing national strategy is Sweden's **Smart industry strategy** (SIS)[23] launched in June 2016 with the vision of becoming a world leader in the innovative and sustainable industrial production of goods and services. The strategy supports industry to be at the forefront of the digital transformation and adoption of sustainable production methods. **Testbed Sweden**[24] is one of the four SIS focus areas, building on the idea that test and demonstration environments are essential to meet the challenges faced by companies and the public sector and at the same time are essential to enhance the country's' image as a competitive environment for innovation development worth investing in. Research Institutes of Sweden (RISE) — the Swedish RTO — is managing over half of the country's testbeds and demonstration facilities, which are open to industry, academia, SMEs and the public sector.

***Example**: AstaZero[25] is a Swedish test environment which is unique in the world. It can be used by industry to develop, test or certify new traffic safety solutions, making it possible to test all aspects of active safety in one place. It was inaugurated in 2014 with an initial budget of 500 MSEK, half of which was funded through ERDF, Sweden's Innovation Agency (Vinnova) and regional public grants, while the other half was funded through bank loans guaranteed by five industrial partners. The Vinnova support was made through the Swedish Strategic innovation programme for Vehicles, allowing SMEs, start-ups and universities to use the infrastructure. After four years of operations, AstaZero has a usage rate of 120 % and has already benefited from an extension.*

In Germany, the strategic **Industry 4.0 initiative**[26] includes important actions for test bed activities. The Federal Ministry of Education and Research (BMBF) supports the testing of innovative Industry 4.0 components by SMEs at existing testbeds with a specific funding announcement. In addition, the BMBF has established a central contact and coordination office at the University of Stuttgart to advise SMEs, in particular on the selection of the most appropriate testbeds for specific projects.

These actions are accompanied by an initiative created by companies and associations from Platform Industrie 4.0 to provide appropriate information to interested parties in as many industries and manufacturing technology fields as possible. The association **Labs Network Industrie 4.0**[27] acts as a one-stop shop for SMEs to test their innovations in a network of test beds. There are currently 72 test labs where users can test and validate innovations as well as receive feedback for standardisation.

***Example:** Research Fab for Microeelectronics Germany[28] (FMD) is a unique platform combining all major publicly funded institutes of Applied research in microelectronics in Germany (11 Fraunhofer Institutes and 2 Leibniz-Institutes). The ERDF provides substantial co-financing to the Fraunhofer*

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[22] Clinatec Platform: http://www.cea-tech.fr/cea-tech/english/Pages/resources-and-skills/technology-platforms/clinatec-platform.aspx
[23] *Smart industry - a strategy for new industrialisation for Sweden*:https://www.government.se/information-material/2016/04/smart-industry---a-strategy-for-new-industrialisation-for-sweden/
[24] *Testbed Sweden:* https://www.vinnova.se/en/m/testbed-sweden/
[25] AstaZero: http://www.astazero.com/
[26] a) Digital Transformation Monitor, *Germany: Industrie 4.0/* https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf; b) Germany Trade and Invest: https://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Industrie-4-0/Industrie-4-0/industrie-4-0-what-is-it.html#1798424
[27] Labs Network Industrie 4.0: https://lni40.de/?lang=en
[28] Research Fab Microelectronics Germany: https://www.forschungsfabrik-mikroelektronik.de/en/Presse/01-06-2017_Forschungsfabrik_Mikroelektronik_stellt_sich_vor.html

Institute for this. When completed in 2020, FMD will have over 12 500 m² of cleanroom facilities for the proto-typing, testing and pilot production of new microelectronic devices. The FMD project is currently a nationally funded initiative of EUR 350 million[29]. Annual operational costs of FMD will be in the range of the initial investment. FMD will create more than 500 jobs in the FMD institutes and leverage at least a 5-fold number of jobs in the industrial sector. Semiconductor sales amounted to some EUR 400 billion in 2017. They are expected to grow to EUR 1 trillion by 2030.

The key objective of the **Netherlands Smart Industry 2018-2021 Implementation Agenda**[30] is to speed up digitisation in Dutch businesses, so that by 2021, the Netherlands will have developed the best and most flexible digitally connected production network in Europe capable of generating savings in energy and materials. One of the five strands of actions is the support of technology infrastructures through Fieldlabs. Fieldlabs meet the need for physical and digital space for experimentation and accompanying facilities, allowing companies and knowledge institutions to develop, test and implement solutions. They ensure an interdisciplinary approach (e.g. manufacturing in combination with ICT) and link that to domains where the Netherlands has a competitive advantage such as agro-food. Since the start of 2018, 32 Fieldlabs are up and running, with a regional, national or international focus, covering areas such as multi-material 3D printing, composite maintenance and repairs, flexible manufacturing, thermo-plastics and industrial robotics. Each fieldlab currently has a turnover of between EUR 0.25 million and EUR 4 million annually, depending on the scope of their operation. There is also the aim to set up a Smart Industry hub in every region to simplify collaboration between these Fieldlabs and facilitate access by SMEs. These hubs will function as the regional Smart industry contact point for businesses.

Example: *The Campione Smart Industry fieldlab offers experimentation and demonstration facilities to make maintenance 100% predictable. It is about condition-based maintenance where sensors monitor the status of installations to predict exactly when maintenance is needed. This Fieldlab helps companies to collect and analyse real-time information about the state of their production infrastructure in order to be able to carry out maintenance on time (instead of too early as with planned maintenance or too late as with corrective maintenance). With these measures, the availability of plant installations increases whereas costs decrease.*

The Finnish Government programme for 2015-2019 includes national innovation policies aimed at diversifying the structure of business and industry and improving the level of research activity[31]. In 2017, Finland's Research and Innovation Council published a vision and a roadmap up to the year 2030 that are largely based on the government's priorities and the priorities of the Finnish National Reform plan. Part of the strategy to make Finland 'the most attractive and competent environment for experiment and innovation' includes the development of competence platforms and growth ecosystems. These competence platforms are expected to speed up the introduction of new solutions by offering the research community and the business sector joint environments for testing new technologies. One of the long-term objectives would be to create several business-run billion-euro growth ecosystems[32].

Example: *The world's first test area for autonomous shipping has been established in Finnish national waters. Covering an area of approximately 18km by 8km and managed by DIMECC[33], the site is open to all parties and provides an infrastructure, which enables industries, research centres and other institutions to test automated shipping. Although supported by Finland, the area is open to non-Finnish users and underpins Europe's technological lead in this rapidly developing field.*

[29] Includes support received from the ERDF.
[30] https://www.smartindustry.nl/wp-content/uploads/2018/03/SI-Implementation-Agenda-2018-English.compressed.pdf
[31] *RIO Country Report Finland* 2017: https://rio.jrc.ec.europa.eu/en/country-analysis/Finland/country-report
[32] Vision and road map of the Research and Innovation Council Finland: https://valtioneuvosto.fi/documents/10184/4102579/Vision_and_roadmap_RIC.pdf/195ec1c2-6ff8-4027-9d16-d561dba33450/Vision_and_roadmap_RIC.pdf.pdf
[33] Digital, Internet, Materials & Engineering Co-Creation: https://www.dimecc.com/

In 2017, **the UK government** launched the UK industrial strategy to strengthen the UK's innovation, skills, infrastructure, business environment and places[34]. The strategy sets a target of investing 2.4 per cent of gross domestic product (GDP) in R&D over the next 10 years. One of the actions, under the strategy is the government's plan to develop and invest in Catapult centres, which bring together businesses, scientists and engineers to work side-by-side on late-stage research and development. In addition, approximately EUR 427 million will be invested in digital infrastructure.

Example: *The UK's Catapults Programme is a network of physical centres providing access to equipment and technical and business expertise. Collectively, the centres operate over €1bn*[35] *worth of open access research and demonstration facilities for the benefit of UK industry in areas ranging from High Value Manufacturing to Cell & Gene Therapy. Many of the catapult centres receive substantial co-financing from the ERDF. To date, this has delivered supported close to 6000 SMEs as well as large corporates*[36].

In the follow-up of its Digitising European Industry initiative[37] adopted in April 2016, the Commission encouraged the launch and further development of such national strategies. Several of the 15 national initiatives on digitising industry in Europe are planning, as a prominent feature, to support technology infrastructures[38]; many – particularly in Southern and Eastern Europe – co-finance them with ERDF budgets.

2.3. EU initiatives

The European Commission funds various initiatives, which directly or indirectly support technology infrastructures, notably under the European Regional Development Fund (ERDF) and under the Framework Programme for Research and Innovation, Horizon 2020.

ERDF focuses on investments relevant for regional socio-economic development and territorial cohesion, including national and regional innovation ecosystem development and aiming at industrial transformation, via a broad innovation concept. **Smart Specialisation Strategies** set out the priorities for ERDF investments. These Strategies were developed via a bottom-up entrepreneurial discovery processes at national or regional level[39]. Many ERDF programmes invest in the building and upgrading of research and innovation infrastructures, technology absorption and innovation diffusion to all regions and economic sectors. Since Cohesion policy aims at economic, social and territorial cohesion, reducing disparities and structural adjustment of lagging regions and the conversion of declining industrial regions, around 55% of the ERDF for research and innovation goes to the EU-13 countries and around 27% to Southern Europe (ES, PT, IT, GR). Building on these initiatives and the ESI Funds implementation record the Commission emphasises the need to foster the take-up of advanced technologies and to overcome bottlenecks for innovation diffusion in view of industrial transition and economic transformation in all EU regions in its proposals for the post-2020 ERDF.

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[34] The UK's Industrial Strategy: https://www.gov.uk/government/topical-events/the-uks-industrial-strategy

[35] Includes support received from the ERDF.

[36] Cross Catapult Network Report 2017: https://s3-eu-west-1.amazonaws.com/media.www.catapult/wp-content/uploads/2017/08/22143240/cross-catapult-network-report-20171.pdf

[37] COM(2016)180, *Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on establishing the specific programme implementing Horizon Europe – the Framework Programme for Research and Innovation*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0436

[38] Industrie 4.0 Oesterreich (Austria); Made different – Factories of the future (Belgium); Průmysl 4.0 (Czech Republic); Industrie 4.0 (Germany); Manufacturing Academy of Denmark MADE (Denmark); Industria Conectada 4.0 (Spain); Alliance pour l'Industrie du Futur (France); IPAR4.0 National Technology Initiative (Hungary); Industria 4.0 (Italy); Pramonė 4.0 (Lithuania); Digital For Industry Luxembourg (Luxembourg); Smart Industry (Netherlands); Initiative and Platform Industry 4.0 (Poland); Indústria 4.0 (Portugal); Smart Industry (Sweden).), as analysed in https://ec.europa.eu/futurium/en/implementing-digitising-european-industry-actions/national-initiatives-digitising-industry.

[39] See Commission Communication "Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth" COM(2017) 376 final

The Cohesion Policy supports the setup of **Thematic Smart Specialisation Platforms**[40]. Under these platforms, so far 28 partnerships were formed to connect regional policy makers around related smart specialisation priorities in view of learning from each other and developing joint priorities for investments, map the research and innovation capacities in the participating regions that are specific to the topic of the thematic partnership and identify gaps. Building on this, the Commission launched in 2017 a **pilot for interregional innovation investments**. The nine selected partnerships receive further support to commercialise and scale-up interregional innovation projects that can create or reshape European value chains and attract private investment for promising innovation projects. The pilots also explore and strengthen synergies between different EU funding instruments (ESI Funds, the EFSI, Horizon 2020, COSME)[41] and provide input to the shaping of the new Interreg instrument for interregional innovation investments that the Commission has proposed. [42]

Horizon 2020 focuses on excellence, mainly by funding trans-national research and innovation activities and promoting industrial leadership. Specifically tailored actions for technology infrastructures have been included in the Horizon 2020 Work Programmes, with an investment of approximately EUR 1.2 billion foreseen up to 2020.

a) Pilot lines and Open Innovation Test beds (OITBs) for Materials

Between 2014 and 2017, the Commission invested **EUR 225 million in supporting 24 nanotechnology and advanced material pilot line projects**, comprising 80 pilot lines operating across Europe (mainly at TRL 4 to 7). The main objective was to develop cost effective and sustainable industrial scale facilities to provide SMEs with testing and validation services before commencing pilot production. A further **EUR 240 million** is planned for 2018-2020 to broaden the concept of these pilot lines through the creation of open innovation test beds (OITBs). These will be set up to provide technology access as well as regulatory and legal support services for any user seeking to develop advanced materials and nano-enabled products from validation in a laboratory to prototypes in industrially-relevant environments.

The OITBs will help all users, especially SMEs, to

- **minimise costs** and lower technological risks;
- **tap into relevant competences and services** including risk-benefit assessments to ensure regulatory compliance as well as the implementation of standardisation efforts early in the technology development process, and;
- **access business services** such as mentoring and market analysis.

Also, to help link technology providers, users, technology up-takers, policy makers, investors and other actors along industrial value chains, the Commission has launched the **'European Pilot Production Network'** (EPPN), granting approximately EUR 1 million in funding. The EPPN has developed an online mapping tool detailing the locations and services of existing pilot lines across Europe[43].

Example: CO-PILOT *is an open access facility for the production of high quality multi-functional nano-composites on a pilot scale. It includes a 10-litre-scale pilot plant operating in the South of the Netherlands by the Dutch RTO TNO and one 100-litre-scale pilot plant operating in Bavaria by the German RTO Fraunhofer. The pilot line is able to produce 10 to 100-kg nano-composite products,*

[40] http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms
[41] http://europa.eu/rapid/press-release_IP-17-5108_en.htm
[42] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A374%3AFIN
[43] European Network for Pilot Production Facilities and Innovation Hubs: https://www.eppnetwork.com/, coordinated by INL (**Portugal**), with partners from **Belgium**, **Sweden** and the **UK**.

characterise these, and validate their performance. Based on the results, the management takes decisions whether to progress new nano-composite products to full industrial development for use, for instance, in the construction sector[44]*. In 2018, the CO-PILOT facilities were used in B2B projects by 11 enterprises, including SMEs, with five of these projects taking place in the cost category of EUR 100,000-500,000.*

b) Pilot lines for manufacturing

Factories of the Future (FoF) is a public-private partnership to help manufacturing enterprises — SMEs in particular — improve their technological capacity to adapt to environmental pressures and adequately respond to increasing global consumer demand for greener, more customized and higher quality products. FoF receives public support under Horizon 2020 — notably the NMBP and the ICT Programmes – triggering almost five times that amount in private investment by the industry.

As evidenced on the innovation portal of the European Factories of the Future Research Association (EFFRA)[45], there have been significant results and achievements to date and efforts are underway to complement innovation actions with dedicated pilot line projects that demonstrate the following:

- easy and fast reconfigurable machinery and robots; this is essential for reacting to rapid market changes and meet the increasing need for highly complex products;
- the full potential of metal additive manufacturing under real manufacturing conditions, with significantly improved quality, robustness, stability, repeatability, speed and right-first-time manufacturing serving as a flagship example for others;
- pilot lines for modular factories, starting from existing test beds that are sufficiently flexible to allow for the introduction of multiple modular process units;
- pilot lines for large-part high-precision manufacturing.

More than EUR 100 million have been invested under Horizon 2020 in the Factories of the Future pilot lines. Participation of SMEs exceeds 35 %. Moreover, recommendations of the mid-term Assessment report highlights the need to encourage the exploitation of results and the transferability of technical solutions within the sector and along the supply chain. This assumes an increase in available facilities.

Example: *The Horizon 2020 project, Rapid Reconfiguration of Flexible Production Systems (ReCaM)*[46] *brought together nine partners from industrial end-users (mainly SMEs), technology providers and research institutions. The project aimed to demonstrate how a set of Plug and Produce mechatronic objects could be used for the rapid reconfiguration of flexible production systems equipped with conventional production planning and scheduling tools at a high technology readiness level (TRL 7). These Plug and Produce mechatronic objects should be able to auto-program and self-adjust to the required tasks by utilizing parametric capabilities. A pilot line was set up under this project and was tested by SMEs. The ReCaM project has accordingly helped these SMEs with their ideas and concepts, providing a forum where other companies could challenge these ideas and concepts and enabling the SMEs to adapt quickly to new market trends.*

[44] CO-PILOT: http://www.h2020copilot.eu/, coordinated by TNO (**the Netherlands**) with partners from **Germany**, **France**, **Ireland**, the **UK** and **Switzerland**.

[45] https://www.effra.eu/effra-innovation-portal

[46] https://recam-project.eu/; *For example, DGH, a systems integrator that creates Industry 4.0 opportunities in diverse industrial sectors, e.g. automotive, food & beverage, aeronautics, energy. The project has enabled DGH to acquire expertise with respect to manufacturing line versatility and flexibility, one of the most important pillars of DGH's growth strategy in the coming years. By developing solutions for these key elements, DGH can now implement innovative ideas to optimise the manufacturing lines of its customers. The project also helped SME partner nxtControl, whose business it is to be a partner and consultant to companies preparing for digitisation, to advance its know-how in the area of production process, re-configuration and Cyber Physical Systems.* Coordinated by Bosch (**Germany**) with partners from **Austria**, **Finland**, **Italy** and **Spain**.

c) Technological infrastructures in the transport sector

Technology infrastructures have been an integral part of EU Transport Research programmes, for all transport modes. They significantly help validating transport vehicle computational designs, advancing the TRL of components and integrated vehicles/vessels/aircrafts, providing the means of compliance with required certification.

Specifically, EU Transport Research programmes have supported and advanced transport technology infrastructures such as wind tunnels (for trains, cars, trucks, and airplanes), anechoic chambers (e.g. for internal and external acoustics for cars and aircraft propulsion), dynamic driving simulators for cars, crash tests facilities (e.g. for cars and aircraft fuselage sections), facilities for the dynamic structural testing of materials, and structures and hydrodynamic test facilities for vessels.

In addition to these traditional technology infrastructures, the digitalisation and electrification of the transport system give rise, for example, to digital twin development infrastructures, electric benches for the validation of new electric networks and configurations, energy storage testing, alternative fuels validation, interoperability in rail, and the combination of advanced multi-disciplinary optimization design tools with High Performance Computing.

In many cases, technology infrastructures have the characteristic to serve as research infrastructures too and being operated by academia and national research establishments. This makes them unique and of very high added value not only for industry but also for research and education. That is why all seven Strategic Transport research and innovation (STRIA) roadmaps call for investments in transport technology infrastructures.

Transport technology infrastructures offer services such as:

- **Testing for the further development** of components, systems and integrated vehicles;
- **Testing for validation at an environment as close as possible to the operating one**;
- **Testing for the development of standards;**
- **Testing for certification** (e.g. EASA, EMSA);
- **Developing future skills and training,** linking industry with academia;
- **Providing a unique and certified environment at European level**, ensuring a level-playing field (e.g. emission measurements, life-cycle analysis);
- **Supporting the supply chain** — linking SMEs and all tier suppliers with vehicles integrators;
- **Exploiting synergies between different transport modes and other sectors** (i.e. energy, materials, data-driven analytics)

A positive example of long-standing cooperation between Member States with substantial economic impact is the DNW[47] wind tunnel technology infrastructure. Those facilities, located in both Germany and the Netherlands, have been co-financed by the respective governments and additionally supported by the EU Research framework programmes. They have contributed to innovative European and international transport research programmes and benefited several European transport stakeholders.

Example: *European industrial Leadership in aeronautics has been supported for more than five decades by wind tunnel technology infrastructures. The European industry is demonstrating today, within the Clean Sky programme, the Natural Laminar Flow (NLF) wings within the BLADE*

[47] German-Dutch Wind Tunnels: https://www.dnw.aero/

demonstration project, based on joint technology infrastructures that were supported by more than 40 European research projects, such as FP6-TELFONA.

The Horizon 2020 RINGO project[48] *emphasizes that substantial investments in transport technology infrastructures, both in new facilities and upgrades or modifications of existing ones, are required to sustain innovation and economic growth in Europe.* ***The project received EUR 2 million in funding*** *and designed a cohesive and coordinated approach to identify and assess the needs, gaps and overlaps for strategic aviation research and technology infrastructures in Europe. It has also analysed potential sustainable business models and funding schemes for the maintenance and improvement of existing and new research and technology infrastructures towards in line with the Flightpath 2050 goals.*

Similar technological developments using hydrodynamic test infrastructures, combined with other technological advancements, have today enabled the European maritime industry to claim a 90%[49] *market global share in large passenger ships.*

The Shift2Rail (S2R) Joint Undertaking[50] *is focusing its research and innovation activities on delivering innovative solutions for cost efficient and reliable trains, advanced traffic management and reliable high-capacity infrastructure for passengers and freight. Technical demonstrators are being developed with a system approach, and S2R is already conducting extensive lab simulation and digital testing, but shared test facilities are still lacking to validate results and perform certification for new trains and infrastructure components.*

d) Digital Innovation Hubs (DIH)

Digital Innovation Hubs (DIHs) are not-for-profit one-stop-shops that support companies, notably SMEs, and the public sector in their digital transformation. In its Digitising European Industry[51] communication adopted in April 2016, the Commission announced plans to invest €500 million from Horizon 2020 (2016-2020) for the development of digital innovation hubs, their networking and innovative experiments with SMEs. This investment in digital innovation hubs should allow every industry, large or small, high-tech or not, to get access to knowledge and testing facilities in the latest digital technologies. A breakdown of this investment throughout Horizon 2020 is provided in Annex I.

At the core of the DIH, there is normally a research and technology organisation (RTO) or a university lab in collaboration with partners offering services such as:

- **Fast and easy access to technology infrastructures** (**'test before invest')**: experimentation with new digital technologies — software and hardware (e.g. Artificial Intelligence (AI), High Performance HP computing (HPC), Cybersecurity, Blockchain, Photonics and 3D printing) to understand new opportunities and return on investments
- **Skills and training** to make the most of digital innovations: boot camps, traineeships, exchange of curricula and training material
- **support to find investments**
- **innovation ecosystem and networking** opportunities

[48] Coordination action focused on 'Infrastructures – Needs, Gaps, and Overlaps': http://www.ringo-project.eu, coordinated by DLR (Germany), with partners from Belgium, France, Italy, the Netherlands, and Spain.
[49] Research and Innovation in Waterborne Transport: https://ec.europa.eu/research/transport/pdf/waterborne_transport_saucisson_HR.pdf
[50] Shift2Rail: https://shift2rail.org/
[51] COM(2016)180, *Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on establishing the specific programme implementing Horizon Europe – the Framework Programme for Research and Innovation*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0436

From 2014 to 2017, DIH initiatives including the Smart Anything Everywhere (SAE) and the ICT Innovation for Manufacturing SMES (I4MS) initiatives have supported more than 150 Digital Innovation Hubs as well as 370 digital transformation experiments involving 500 Start-ups, SMEs and mid-caps.

The Commission has created a European catalogue of DIHs a repository that includes over 240 existing hubs across Europe and that will keep growing with new additions in the future.[52] In order to bring all regions of Europe, and notably the regions with an underserved offer of digital innovations, coaching and mentoring initiatives have been launched. For example, the Smart Factories in new EU Member States[53] project provided training and mentoring to 34 organisations, while the DIH Enhanced-Learning Programme (DIHELP)[54] will offer a coaching and mentoring programme in 2019, to support the establishment and scaling-up of another 30 regional DIHs.

Example: *The Laboratory for the Integration of Systems and Technology (LIST) is the Paris-Saclay Competence robotics centre (CC) in the Ile-de-France regional DIH (DIGIHALL). As part of its regional and European activities, the Paris-Saclay robotics CC offers industries, especially SMEs, access to its equipment to conduct proof- of- concept- type experiments. These experiments aim to demonstrate that innovative solutions involving robotics, high-performance computing, Internet of Things and Artificial Intelligence are increasingly feasible. They also aim to initiate technology transfer and facilitate the uptake of digital technologies. The robotics lab possesses a large set of robotics equipment, including prototypes, off-the-shelf components (conveyors, sensors, safety systems) and robots with their supervision system. This equipment requires regular maintenance and replacement*[55] *in order to propose solutions at the forefront of innovation and especially advanced solutions for SMEs.*

Example of ERDF-supported DIH*: Digital Innovation Hub of Eastern Slovenia (DIGITECH SI - East) is a regional innovation ecosystem enabled and supported by the industry driven virtual living laboratory LENS Living Lab, Toolmakers Cluster of Slovenia, Competence Center ROBOFLEX and Competence Center ALaseR. The mission of DIGITECH SI – East is to help industry business partners and other stakeholders get the latest, knowledge and technology know-how on Industry 4.0, related key enabling technologies, supporting systems and services.*[56]

e) SMEs' access to Key Enabling Technologies - KETs Technology Centres (KETs TCs)

KETs Technology Centres (TCs) help industry, and in particular SMEs, to develop and produce new KETs-based products, helping them cross 'Valley-of-Death' and go from lab to market. They are public or private organisations carrying out applied research and close-to-market innovation, helping companies to reduce the time it takes innovative ideas to reach the market. Key enabling technologies covered by these TCs include micro and nanoelectronics, nanotechnologies, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies having applications in multiple industries.

KET TCs services may include:

- access to technology expertise and facilities for validation
- proof of concept/lab testing
- prototype development and testing
- **pilot production** and demonstration/pilot lines

[52] Digital Innovation Hub Catalogue: http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool.
[53] Smart Factories in New EU Member States: https://smartfactories.eu/
[54] Digital Innovation Hubs Enhanced Learning Platform: http://dihelp.eu/
[55] In general an equipment has a five-year life duration and becomes obsolete after ten years. Maintenance represents 10% to 20% of the cost of an equipment. Access cost is approximately EUR 1000 per day.
[56] http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1487/view

- product validation/**certification.**

So far, over 250 KETs TCs have been identified according to specific criteria demonstrating their capacity to collaborate with SMEs on close-to-market research and innovation. Information about these KETs TCs the services they offer is available using the KET-TC mapping tool[57].

Example: *The KET4CleanProduction has received EUR 4.9 million in Horizon 2020 funding to create a one-stop access platform to facilitate SME connectivity to KETs TCs[58]. Micro grants of max EUR 50 000 are available for transnational cooperation between SMEs and at least 2 KET TCs, aim who are seeking to integrate key enabling technologies to solving clean production challenges.*

Various other initiatives supported under the COSME programme also explore models for the sustainable operation of European Collaboration networks of KETs Technology Centres. For instance, the **Advanced manufacturing (ADMA) Support centre** has received **EUR 2.4 million** to help SMEs adopt advanced manufacturing solutions[59].

f) European Institute of Technology (EIT)

The EIT supports the development of dynamic pan-European partnerships between leading universities, research labs and companies called Knowledge and Innovation Communities (KIC). These KICs cover Climate, Digital, Food, Health, InnoEnergy innovation and Raw Materials[60]. A new KIC for advanced manufacturing was selected in December 2018.

The mission of KIC Raw Materials is to enable the sustainable competitiveness of the European minerals, metals and materials sector along the value chain by driving innovation, education and entrepreneurship. KIC Raw Materials aims to significantly enhance innovation in the raw materials sector by sharing knowledge, facilitating matchmaking activities, **developing innovative technologies** and supporting business creation. These activities are worth mentioning:

The KIC Raw Materials Upscaling Projects[61] are innovation projects at or near a TRL of demonstration or prototyping and need a specific step to be taken. These projects aim at:

- the integration of existing technology
- de-siloing and value chain cooperation
- Bringing technologies in the market

Projects will typically combine a mix of industrial, R&D and university partners. The added value of the upscaling projects comes from the experimenting, testing and validation of products and technologies demonstrating their feasibility in prototypes or in full scale. **Four calls have been launched so far with a total budget of EUR 61 million.**

Example: *The AutoBatRec2020 project[62] aims to develop an industrial battery recycling process in Europe that provides a source of sustainable raw materials for its high-tech industry, essential for the sustainable implementation of electric mobility and green energy in Europe. The consortium is made*

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[57] SMEs' Access to Key Enabling Technologies: https://ec.europa.eu/growth/tools-databases/kets-tools/kets-tc/map

[58] KET4CleanProduction: https://www.ket4sme.eu/, coordinated by Steinbeis (**Germany**) with partners from **Austria**, **Belgium**, **Bulgaria**, **Croatia**, **Denmark**, **Finland**, **France**, **Greece**, **Hungary**, **Ireland**, **Latvia**, **Portugal**, **Slovakia**, **Slovenia**, **Spain**, **Sweden** and the **UK**.

[59] Tender: *Access for SMEs to advanced manufacturing support - European advanced manufacturing support centre*: https://etendering.ted.europa.eu/cft/cft-display.html?cftId=2746

[60] European Institute of Innovation and Technology: https://eit.europa.eu/

[61] a) Developing raw materials into a major strength for Europe: https://eitrawmaterials.eu/innovation/; b) EIT RawMaterials Call for KAVA Upscaling projects: https://eitrawmaterials.eu/wp-content/uploads/2018/10/EITRM_Upscaling-Call-Text-KAVA-6-1.pdf

[62] AutoBatRec2020 innovation project for smart recycling of waste traction batteries from electric vehicles: https://eitrawmaterials.eu/autobatrec2020-innovation-project-for-smart-recycling-of-waste-traction-batteries-from-electric-vehicles/, coordinated by Fraunhofer (Germany) with partners from **Austria**, **Belgium** and **France**.

up of the battery recycler Umicore, the battery producer Samsung, the automotive group Daimler and the recycling plant manufacturer ImpulsTec. This covers the whole value chain and is supported by the respective R&D skills of TU BA Freiberg, CEA and Fraunhofer for batteries, recycling, process automation and resource strategies.

The KIC Raw Materials network of infrastructure projects aims to coordinate the use and commercialisation of the technology infrastructures of the KIC Raw Materials partners to:

- facilitate the access to infrastructure for those that need it by acting as a broker between partners and customers. This role is organised by appointing a single point of contact for an infrastructure network hub (focused on a specific topic/domain);
- coordinate strategies between partners for investment in infrastructure, leading to the progressive development of a technical infrastructure for the entire KIC partnership, where useless redundancies are avoided and complementary equipment is acquired to fill identified gaps.

So far, a **total budget of EUR 10 million has been allocated to this activity.**

Example: *EXTREME: Substitution of critical raw materials in components and coatings used under extreme conditions*[63]*. The project brings together advanced equipment and the high-level expertise of partners to support the design and modelling of materials and products, the development of materials (bulk and coatings) and related process optimizations, characterisation and functional testing, the recovery and recycling of materials, and life-cycle analysis. One of the objectives of the project is to provide services to enterprises, industries and research institutions in the interested sectors (manufacturing, machining, transport, construction, energy, etc.).*

To fulfil the vision of making the partners' infrastructure available through a single point of contact, the KIC Raw Materials networks of infrastructure are evolving into a virtual lab that can serve as a one-stop-shop to contact partners and contract their capabilities for testing and piloting.

g) Open Access to Joint Research Centre facilities

The opening of the physical facilities of the Joint Research Centre (JRC)[64] is part of the JRC Strategy 2030 'Infrastructures Fit for Purpose' that envisages opening up the JRC's facilities to external use, with the purpose of giving access to European researchers and industry and to raise the value and visibility of the JRC's facilities.

The JRC maintains 38 physical facilities suitable for opening access to external users working in the nuclear and radiological fields (Euratom Laboratories) and in chemistry, biosciences/life sciences, physical sciences and ICT. These facilities are located at the Ispra (Italy), Geel (Belgium), Karlsruhe (Germany) and Petten (the Netherlands) sites. Users from EU Members States and Horizon 2020 associated countries can access JRC facilities through two modes: **relevance-driven**, based on the payment of the additional costs of access and on a peer-review selection process following a call for proposals; or **market-driven**, based on the payment of the full costs of access following a selection by the JRC.

All data generated in the relevance-driven mode must be made available to the public via open access schemes.

[63] EXTREME: Substitution of CRMs in components and coatings used under extreme conditions: https://eitrawmaterials.eu/project/extreme/; coordinated by ENEA (**Italy**) with partners from **Finland**, **Hungary**, **the Netherlands**, **Poland**, **Slovenia** and **Sweden**.
[64] Open access to JRC Research Infrastructures: https://ec.europa.eu/jrc/en/research-facility/open-access

Since the strategy for opening access to JRC facilities was implemented in June 2017, the JRC has opened 18 calls covering 12 facilities: 6 in the non-nuclear area at Ispra (nano biotechnology and safety and security of buildings) and Petten (Energy storage), and 6 in the nuclear area in Geel and Karlsruhe. Overall, a total of 69 eligible proposals have been received from 24 countries, and 58 proposals have been accepted. The accepted proposals total 87 User institutions and 199 users who have or will have access to JRC facilities.

Example: *Reaction Wall, European Laboratory for Structural Assessment (ELSA) at Ispra*[65]*: this facility consists of a reinforced concrete vertical wall and a horizontal floor rigidly connected together to test the vulnerability of buildings to earthquakes and other threats to structural stability. The ELSA Reaction Wall is the largest facility of its kind in Europe and one of the largest in the world. It allows full-scale testing and demonstration tests of civil infrastructures (i.e. buildings and bridges) at medium to high TRL levels, and has been a key contributor in pre-normative research to the drafting of the EN Eurocodes published by CEN.*

3. KEY FINDINGS AND MAIN CHALLENGES

Technology infrastructures are supported by a mix of regional, national and European initiatives. The rationale for all of these initiatives is that with rising technological complexity industry's competitiveness and ability to succeed on global markets critically depends on possibilities to test, validate and upscale new technological solutions. Investing technology infrastructures is also key for supporting the translation of research results into innovations and for helping small high tech firms to scale up and thereby improving Europe's overall innovation performance.

Technology infrastructures require high investment both in the set-up and for keeping up with the state-of-the-art. Despite the income generated from their clients, many technology infrastructures depend on public funding, especially in high-risk technological areas where there is no possibility of obtaining risk premiums for the continuous and large investment needed to remain state-of-the-art. Due to market failure, there is underinvestment from the private side. Therefore, public investment in technological infrastructures is indispensable and ensures that the high cost of pilot and demonstration actions can be mitigated, for instance, for SMEs through the availability of open access capabilities. Moreover, the positive externalities for the innovation system as a whole (i.e. job creation and investments in new production lines at the technological infrastructures customers' premises) justify public support to open technological infrastructures.

As investments in infrastructure can be state-aid relevant if public support is involved so too can equipment investment, upgrading and innovation support and advisory services. The Commission therefore works in close cooperation with national and regional authorities to facilitate and clarify the combined use of different funds in relation to state aid rules, public procurement and interregional cooperation.[66]

The policy and financial support to technology infrastructures is a global phenomenon. The United Nations Conference on Trade and Development (UNCTD) 2018 global survey[67] of industrial policies showed that in over the past 10 years alone, at least 101 economies accounting for more than 90 per cent of global GDP have adopted formal industrial development strategies.

The formulation of new strategies has increased in the last 5 years. More than 80 % of the investment policy measures recorded since 2010 are directed at the industrial system, i.e. manufacturing,

[65] European Laboratory for Structural Assessment: https://ec.europa.eu/jrc/en/research-facility/elsa
[66] COM(2017) 376 final: Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth: http://ec.europa.eu/regional_policy/sources/docoffic/2014/com_2017_376_2_en.pdf
[67] Investment and new industrial policies: http://worldinvestmentreport.unctad.org/world-investment-report-2018/

complementary services and industrial infrastructures. The survey also showed that three quarters of funding agencies have specific promotional schemes to upgrade breakthrough technology in industry. China has targeted a leadership position in the key enabling technologies of the future, from artificial intelligence to biotech and robotics, exposing countries in which these high-tech industries account for a large share of economic growth Chinas' strategy[68].

Finally, the stocktaking of the current technology infrastructure landscape, together with the stakeholder analysis gathered in 2017 and 2018[69], shows large regional differences in terms of the availability of technology infrastructure support, fragmentation, risk of duplication of activities, difficulties of transnational accessibility as well as a lack of mechanisms to identify industry needs or missing infrastructure capacity. Few of the national strategies focus on encouraging access to users from other Members States and it is evident that there are discrepancies in terms of investments between Member States. It is equally evident that better synergies and strategic programming coordination between Digital Europe, the Regional Development and Horizon Europe funds need to be sought to create leverage effects in terms of mobilising national and private funding as well as improving governance and partnerships with regional and industrial actors.

All this points towards the conclusion that there is scope for the EU together with Member States to be more ambitious, setting out a shared vision and jointly developing a European approach for technology infrastructures to support industry scale-up and technology diffusion at EU level.

Based on the above the following challenges would need to be addressed.

CHALLENGE 1 – VISIBILITY

With the increasing speed and complexity of innovation and the high capital investment needed, **SMEs and industrial start-ups cannot afford to invest in their own infrastructures**; they have to rely selectively on open and shared infrastructures. However, with the exception of the existing offer by the Digital Innovation Hubs, **industry, and SMEs in particular, in over half of EU Member States are not likely to find the technology infrastructure services and facilities they need**[70]**.** The challenge of identifying technology infrastructure needs and finding relevant technology infrastructures is deemed to be perpetuated by a general limited awareness of what provision *does* exist, e.g. where to access infrastructures, what technology services are on offer, and awareness of how those infrastructures can be linked and networked to value chain orientation.

Moreover, SMEs may often lack the necessary knowledge and resources to dig into various mapping facilities and services and find what could match their needs. Companies' search for infrastructures are often complex and non-linear. SMEs often have to adopt a 'trial and error' approach to their infrastructure needs - not just because local or regional infrastructure is lacking, but also because they frequently cannot be certain (especially in the early stages of exploration) what type of support/provision they require.

An initiative has been launched by the European Commission to feed information on all these initiatives into a common mapping tool as announced in the Communication adopted in July 2017: *Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth*[71].

[68] MERICS Papers on China, *Made in China 2025*: https://www.merics.org/sites/default/files/2017-09/MPOC_No.2_MadeinChina2025.pdf

[69] Workshop Report on "Good practices on increased accessibility of research/innovation infrastructure to industry for testing, demonstration and co-creation" (2017): https://ec.europa.eu/jrc/communities/community/european-tto-circle/event/workshop-best-practices-opening-rtos-researchinnovation

Towards a European approach on industrial research infrastructure, Workshop Reports: https://publications.europa.eu/en/publication-detail/-/publication/db003df9-5269-11e8-be1d-01aa75ed71a1/language-en/format-PDF/source-70442012

*Towards a European approach on industrial research infrastructure, Survey Report:*https://publications.europa.eu/en/publication-detail/-/publication/df68347c-907d-11e8-8bc1-01aa75ed71a1/language-en

[70] Promoting the access of SMEs to KETs Technology Infrastructures: https://www.steinbeis-europa.de/files/action_plan_promoting_the_access_of_smes_to_kets_infrastructures.pdf

[71] COM(2017)376 final.

The mapping and gap analysis produced in the thematic smart specialisation platforms will also be used as input for the mapping exercise. Different models are currently being explored with varying levels of interconnection between the current maps with the European Interoperability Framework[72] and the Sharing and Reuse Framework[73] being used as examples in developing sustainable coherent services approach. The mapping exercise will be implemented through the development of a system of coordination at the EU level with the engagement of Regions and Members States and industry. The coordination should allow high flexibility in responding to concrete industrial needs**.**

CHALLENGE 2 - PRIORITISATION

Technology infrastructures can be domain-oriented (e.g. aviation, medical devices, etc.) and/or technology-focused, public, semi-public and private. There is however, **a lack of strategic oversight on a European level and** a lack of appropriate technology infrastructures for certain sectors. New and upgraded existing technology infrastructures are needed in Europe, but **efforts and investments across the EU require greater coordination** and targeting in order to address industry needs by providing mechanisms to upgrade technology infrastructures and identify those which are or will be missing.

Prioritisation **would** help to reinforce synergies, avoid fragmentation and duplication, and close current and anticipated gaps. This would also lead to economies of scale and increased efficiency by pooling together all available resources – EU, national, regional, local, public and private. Such a response would not only fast track commercialisation of European innovations, boost production, streamline investment and accelerate the pace with which SMEs embrace technological uptake, but ultimately propel the EU's industrial transformation. Depending on the type of infrastructure, this would need to be done at EU level (top-down) or national and regional level (bottom-up). EU level prioritisation, supported by investments under relevant research and innovation programmes, should focus on technology infrastructures which play a strategic and critical role in EU value chains and target a large set of regional, national, European or international clients.

A comprehensive gap analysis covering the provision of technology infrastructures in the EU may involve:

i) identifying infrastructure provision at regional and national level, including privately funded, with further attention to those not known to EU networks or to support mechanisms;
ii) identifying which infrastructures have to be upgraded or developed based on current and future industrial needs;
iii) identifying the place and role of technology infrastructures in strategic global value-chains;
iv) providing the Members States with adequate information for the development of a roadmap for prioritisation and identify resources mechanisms for implementation.

The gap analysis would facilitate the prioritisation in line with the EU's innovative and sustainable industrial policy, Member States strategic agendas and European industries position in future-oriented and globally competitive value chains. A potential outcome of the gap analysis and prioritisation exercise could be the development of an ESFRI-like roadmap for unique and state-of-the-art European technology infrastructures.

[72] COM(2017) 134 final on the European Interoperability Framework- Implementation Strategy. The framework gives specific guidance on how to set up interoperable digital public services.
[73] Guide on *The Sharing and Reuse Framework for IT Solutions:* https://joinup.ec.europa.eu/sites/default/files/custom-page/attachment/2017-10/sharing_and_reuse_of_it_solutions_framework_final.pdf

This would allow a coherent EU innovation ecosystem addressing also the future needs of industry, breaking down silos between technologies and sectors and boosting European competitiveness and RD&I leadership.

As regards **ERDF investments**, prioritisation should be done in a bottom-up process via the entrepreneurial discovery process for the next generation of Smart Specialisation Strategies. These Strategies should include measures for interregional collaboration, including to generate complementarities and synergies with the innovation and economic transformation investments of other countries and regions, along value chains related to their respective smart specialisation priorities. The geographical gaps and missing coverage that has emerged from the stakeholder feedback could further be addressed through the ERDF.

CHALLENGE 3 - ACCESSIBILITY

Quick and easy access to technology infrastructures is crucial to reduce the high capital investment that SMEs and large industries are required to make, from research to commercial deployment (de-risking in regulatory and technology matters). The main reasons companies' access such technology infrastructures are to: i) reduce the cost, length and risk of innovation; and ii) have access to know-how, test and validation facilities.[74]

However, access between regions and across the EU is not easy, and European industries, SMEs in particular, have to face many barriers, such as opacity and **difficulty in finding access conditions**, either because they are not visible or do not exist**.** In addition, the services offered by technology infrastructures need to be translated to the needs of companies, including SMEs, who most of the time **lack awareness of their own technology needs** and require support to identify those needs. Addressing and managing the expectations of users concerning what a technology infrastructure can provide, including the potential limitations arising from IPR, will underpin trusted relationships during the service.

A framework for access conditions to all technology infrastructures targeted in the mapping and gap analysis at the regional, national and EU level is currently missing. Access conditions would need to be industry-driven and support trust and transparency among users and providers. Further work will be needed, among others, to: i) analyse different engagement models concerning the customer-client perspective; ii) elaborate common access conditions; iii) develop a standardised definition of services; iv) facilitate user access and fair conditions regarding in particular contracting arrangements and IPR. Facilitated user access may done by establishing local intermediaries that have both an understanding of the regional services on offer, and an awareness at European level.

In establishing a framework for access, technology infrastructures may take advantage of the experiences of and models developed for the provision for access to research infrastructures[75] and of the related European Charter for Access[76]. They may also draw upon the guidelines for access to open innovation test beds[77], the Horizon 2020 Model Grant Agreement[78] and the modular contract as created by Development of a Simplified Consortium Agreement (DESCA).[79]

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[74] The Field Labs in the Netherlands and several EU funded projects (VIVACE , SARISTU, and TOICA) show that the sharing of testing and demonstration facilities result in lower investment needs and maintenance costs compared to individually managed infrastructures.
[75] http://ec.europa.eu/research/infrastructures/index.cfm?pg=access
[76] http://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf#view=fit&pagemode=none
[77] http://ec.europa.eu/research/participants/data/ref/h2020/other/guides_for_applicants/h2020-im-ac-innotestbeds-18-20_en.pdf
[78] http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-amga_en.pdf
[79] http://www.desca-2020.eu/

CHALLENGE 4 – NETWORKS

Generally speaking, technology infrastructures do not seem fully aware of other technology infrastructures, and this holds true when it comes to competing or collaborating especially for higher TRLs. For instance, there is a huge offer of KET services in Europe, but studies[80] show that these are not always used in a structured way. In addition to this, technology infrastructures that are functioning ecosystems of regional industry do not have internal strategic processes to investigate or even plan for collaboration with other technology infrastructures which go beyond joint research (at lower TRLs).

This includes, for example, IPR strategies for new developments in a joint service offer and the joint use of infrastructures to go at higher TRLs.

Connecting to existing networks of technology infrastructures could also bring visibility to smaller testing facilities whilst potentially addressing over-capacity issues facing larger centres. Networking between technology infrastructures can follow a domain driven or a value-chain driven approach, or a mix of both; a technology infrastructure would chose the approach best suiting their operations.

Technology infrastructures may especially consult the European Enterprise Network (EEN)[81] where they can connect with SMEs through brokerage events and workshops. Networks of technology infrastructures may further apply for EEN membership. Furthermore, examples of hybrid pan-European networks[82] already exist embracing both small-scale technology infrastructures and open innovation labs hosted by research and academia with the aim to benchmark the quality of open innovation ecosystems.

This action would especially concern technology infrastructures primarily serving local customers, in particular SMEs, helping them to embed and strengthen their position in regional value chains – whilst connecting them to global value chains - in order to develop new competitive products and to accelerate their time-to-market.

[80] "Access of SMEs to KETS technological centre's

[81] European Enterprise Network, https://een.ec.europa.eu/

[82] The European Network of Living Labs (ENoLL) is the international federation of benchmarked Living Labs in Europe and worldwide. Founded in November 2006 under the auspices of the Finnish European Presidency, https://issuu.com/enoll/docs/enoll-print

ANNEX I: HORIZON 2020 INVESTMENT IN TECHNOLOGY INFRASTRUCTURES

Figure 3 shows an estimated breakdown of the EC contribution to projects supporting technology infrastructures, i.e. establishing upscaling, demonstration and validation facilities and services for SMEs and industry users. The data is categorised according to the contributions made across the three work programmes of Horizon 2020, i.e. for 2014-15, 2016-17 and 2018-20. For each work programme, the contributions are further categorised according to thematic area. The biggest contributions have largely come from funding in:

- Information and Communication Technologies (ICT), EUR 545.6 million; and,
- Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing (NMBP), EUR 628.4 million. This includes the EUR 123 million contribution for the PILOTS and Factories of the Future (FOF) calls made in the Cross Cutting Activities work programme of 2016-17.

However, since the definition of technology infrastructures is a relatively recent one, and that different domains attribute different words and meanings to demonstration, up-scaling and validation facilities, it is likely that there are projects which have not been identified. Therefore, the figures represented here are considered to be a lower, conservative estimate of the support given over the 2014-2020 period. Note, too, that, as of the time of writing, the calls for the 2019 and 2020 calls are either under way or yet to open. The figures for these years are therefore based on the foreseen budget allocations. Given the competitive nature of the calls, however, the budget allocations represent a reliable indicator of the expected EC contributions.

Considering the information in figure 3 and including the EUR 71 million from EIT projects (Section 2.2f), the total investment for technology infrastructures within Horizon 2020 is estimated to EUR 1.2 billion.

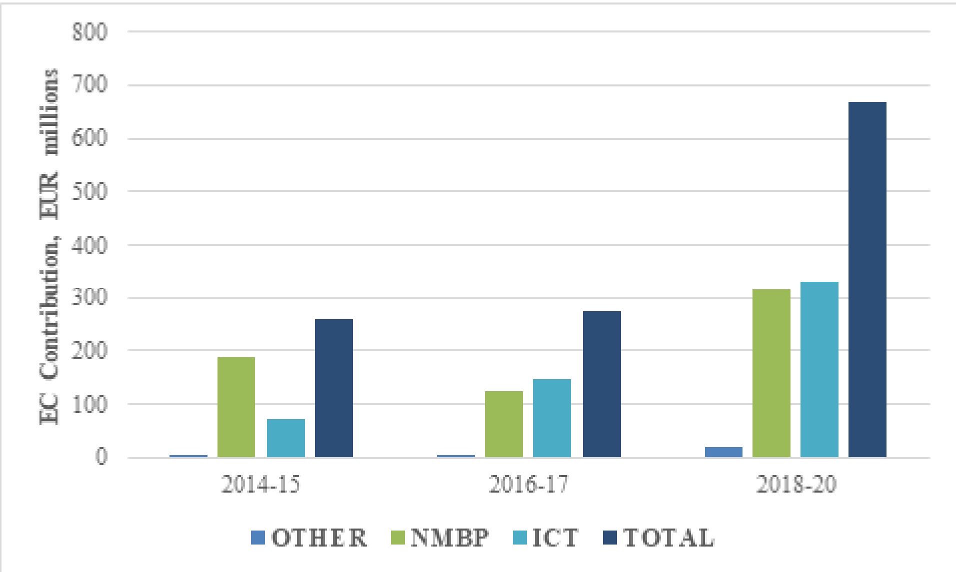

Figure 3: EC contribution towards projects supporting technology infrastructures according to work programme in Horizon 2020.

The remainder of this Annex tabulates the information within figure 3 according to call topic.

Horizon 2020 Work Programme 2014-2015

4. European research infrastructures (including e-Infrastructures)

Topic	Title	Type of Action	Contribution EU (EUR millions)
EINFRA-6-2014	Network of HPC Competence Centres for SMEs (SESAME-NET)	CSA	**2.0**

5.i. Information and Communication Technologies

Topic	Title	Type of Action	Contribution EU (EUR millions)
ICT-01-2014, ICT-02-2014	Smart Anything Everywhere (SAE)	IA	**70.5**
ICT-15-2014	Big data and Open Data Innovation (ODINE)	IA	
ICT-24-2015	Robotics Hubs (ROBOTT-NET)	IA	
ICT-25-2015	Generic micro- and nano-electronic technologies (EUROPRACTICE)	IA	

5ii. Nanotechnologies, advanced materials, advanced manufacturing and processing, biotechnology

Topic	Title	Type of Action	Contribution EU (EUR millions)
NMP-01-2014	Open access pilot lines for cost-effective nanocomposites	RIA	**135.4**
NMP-04-2014	High definition printing of multifunctional materials	IA	
NMP-05-2014	Industrial-scale production of nanomaterials for printing applications	IA	
NMP-08-2014	Scale-up of nanopharmaceuticals production	RIA	
NMP-02-2015	Integration of novel nanomaterials into existing production lines	IA	
NMP-03-2015	Manufacturing and control of nanoporous materials	IA	
NMP-06-2015	Novel nanomatrices and nanocapsules	RIA	
NMP-07-2015	Additive manufacturing for table-top nanofactories	RIA	

Topic	Title	Type of Action	Contribution EU (EUR millions)
FoF-09-2015	ICT Innovation for Manufacturing SMEs (I4MS)	IA	**52.0**
FoF-11-2015	Flexible production systems based on integrated tools for rapid reconfiguration of machinery and robots	IA	

Horizon 2020 Work Programme 2016-2017

5.i. Information and Communication Technologies

Topic	Title	Type of Action	Contribution EU (EUR millions)
ICT-04-2016	Smart Anything Everywhere Initiative	CSA+IA	146.1
ICT-04-2017	Smart Anything Everywhere Initiative	IA	
ICT-12-2016	Net Innovation Initiative (FIWARE)	IA	
ICT-14-2016-2017	Big Data cross-sectorial and cross-lingual data integration and experimentation (EDI, Data Pitch)	IA	
ICT-26-2016	pilot installations in Robotics	IA	
ICT-27-2017	SME & benchmarking actions in Robotics	IA+RIA	
ICT-29-2016	Photonics (EPRISE)	CSA	
ICT-30-2017	Photonics KET (ACTPHAST 4.0)	IA	
ICT-32-2017	Startup Europe for Growth and Innovation Radar	CSA+IA	

5ii. Nanotechnologies, advanced materials, advanced manufacturing and processing, biotechnology 2016-17

Topic	Title	Type of Action	Contribution EU (EUR millions)
NMBP-38-2017	Support for the enhancement of the impact of PILOT projects	CSA	**1.0**

7. Innovation in SMEs 2016-17

Topic	Title	Type of Action	Contribution EU (EUR millions)
INNOSUP-03-2017	Technology services to accelerate the uptake of advanced manufacturing technologies for clean production by manufacturing SMEs	CSA	**4.9**

17. Cross-cutting activities (Focus Areas) 2016-17

Topic	Title	Type of Action	Contribution EU (EUR millions)
PILOTS-01-2016	Pilot lines for manufacturing of materials with customized thermal/electrical conductivity properties	IA	**89.0**
PILOTS-02-2016	Pilot line manufacturing of nanostructured antimicrobial surfaces using advanced nanosurface functionalization technologies	IA	
PILOTS-03-2017	Pilot lines for manufacturing of nanotextured surfaces with mechanically enhanced properties	IA	
PILOTS-04-2017	Pilot Lines for 3D printed and/or injection moulded polymeric or ceramic microfluidic MEMS	IA	

PILOTS-05-2017	Paper-based electronics	RIA	

Topic	**Title**	**Type of Action**	**Contribution EU (EUR millions)**
FOF-12-2017	ICT Innovation for Manufacturing SMEs (I4MS)	IA	**34**

Horizon 2020 Work Programme 2018-2020

5.i. Information and Communication Technologies

Topic	**Title**	**Type of Action**	**Contribution EU (EUR millions)**
DT-ICT-02-2018	Robotics - Digital Innovation Hubs (DIH)	IA+CSA	**155.5**
DT-ICT-06-2018	Coordination and Support Activities for Digital Innovation Hub network	CSA	
ICT-07-2018	Electronic Smart Systems (NEXTS)	IA	
2017-2018	Various EP supported Training Programmes (eg. DIHELP)		
DT-ICT-01-2019	Smart Anything Everywhere	IA + CSA	
ICT-33-2019	Startup Europe for Growth and Innovation Radar	CSA+IA	
DT-ICT-03-2020	I4MS (phase 4) - uptake of digital game changers and digital manufacturing platforms	IA+CSA	**72.0 (foreseen)**
DT-ICT-04-2020	Photonics innovation hubs	IA	**20.0 (foreseen)**
DT-ICT-05-2020	Big data Innovation hubs	IA	**31.5 (foreseen)**
ICT-YY-2020	5G PPP – 5G innovations for verticals with third party services	IA	**50.0 (foreseen)**

5ii. Nanotechnologies, advanced materials, advanced manufacturing and processing, biotechnology 2018-20

Topic	**Title**	**Type of Action**	**Planned EU contribution (EUR millions)**
DT-NMBP-01-2018	Open Innovation Test Beds for Lightweight, nano-enabled multifunctional composite materials and components	IA	**240.0**
DT-NMBP-02-2018	Open Innovation Test Beds for Safety Testing of Medical Technologies for Health	IA	
DT-NMBP-03-2019	Open Innovation Test Beds for nano-enabled surfaces and membranes	IA	
DT-NMBP-07-2018	Open Innovation Test Beds for Characterisation	IA	

DT-NMBP-04-2020	Open Innovation Test Beds for bio-based nano-materials and solutions	IA	
DT-NMBP-05-2020	Open Innovation Test Beds for functional materials for building envelopes	IA	
DT-NMBP-06-2020	Open Innovation Test Beds for nano-pharmaceuticals production	IA	
DT-NMBP-11-2020	Open Innovation Test Beds for Materials Modelling	IA	

Topic	**Title**	**Type of Action**	**Planned EU contribution (EUR millions)**
DT-FOF-04-2018	Pilot lines for metal Additive Manufacturing	IA 50 %	**52.0**
DT-FOF-08-2019	Pilot lines for modular factories	IA 50 %	
DT-FOF-10-2020	Pilot lines for large-part high-precision manufacturing	IA 50 %	**25.0 (foreseen)**

7. Innovation in SMEs 2018-20

Topic	**Title**	**Type of Action**	**Planned EU contribution (EUR millions)**
INNOSUP-07-2019	European Open Innovation network in advanced technologies	IA	**1.5**

9. Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy

Topic	**Title**	**Type of Action**	**Planned EU contribution (EUR millions)**
DT-RUR-12-2018	ICT Innovation for agriculture – Digital Innovation Hubs for Agriculture	IA	**20.0**

ANNEX II: EXAMPLES OF ERDF PROJECTS

Bio Science Park Krems (Austria) offers high-quality laboratory space for enterprises, research institutes, and universities active in medical biotechnology. Programming period 2007-2013. Total Investment: EUR 4.7 million. See: http://ec.europa.eu/regional_policy/en/projects/austria/bio-science-park-krems-more-space-for-high-tech-biotechnology-research

Bio Base North-west Europe Project (Belgium et al): North-west Europe is becoming the go-to hub for bio-based business development. Bringing together experts from eight organisations in five different countries, the project provided networking opportunities and tech-based solutions to over 755 SMEs. Programming period 2007-2013. Total Investment: EUR 6.1 million. See: http://ec.europa.eu/regional_policy/en/projects/belgium/bio-based-booster-shot-for-north-west-europe

Technology vouchers support innovation among Walloon SMEs (Belgium): The vouchers allow SMEs to buy services for technological innovation from accredited research centres to encourage SMEs to make the most of new technological developments. Programming period 2007-2013. Total investment: EUR 12 million.
See: http://ec.europa.eu/regional_policy/en/projects/belgium/technology-vouchers-support-innovation-among-walloon-smes

AdaptSys research and development centre at the Fraunhofer Institute for Reliability and Microintegration IZM, Berlin (**Germany**): the AdaptSys centre aims to develop highly complex electronic systems for a wide range of application areas, evaluating and testing system integration technologies. AdaptSys works with local manufacturers who will benefit from new process innovations. Programming period 2007-2013. Total Investment: EUR 40 million. See: http://ec.europa.eu/regional_policy/en/projects/germany/adaptsys-research-and-development-centre-opens-in-berlin

Fraunhofer centre for marine biotechnology at the University of Lübeck (**Germany**): Programming period 2007-2013. EU Investment: EUR 4.5 million. See: http://ec.europa.eu/regional_policy/en/projects/germany/science-as-a-growth-engine

Pharmapolis Pharmaceutical Science Park (**Hungary**): establishment of the Debrecen Innovation

Alimentary Glycoscience Research Cluster (**Ireland**): Glycoscience, the study of the roles of sugar chains attached to proteins and lipids on cells, has become an increasingly important area of research. Programming period 2007-2013. Total Investment: EUR 5.2 million. See:http://ec.europa.eu/regional_policy/en/projects/ireland/eu-supports-development-of-glycoscience-research-cluster-in-ireland http://ec.europa.eu/regional_policy/en/projects/ireland/eu-supports-development-of-glycoscience-research-cluster-in-ireland

Technopoles project (**Italy**): Spread across the Emilia-Romagna region and incorporating six universities and four research institutes with 34 industrial research laboratories and 11 innovation centres, the 10 Technopoles will complete and strengthen the region's already consolidated high-tech network. Their activity will focus on sectors and areas of business linked to the districts, using the production chains most typical of the region. The centre in Bologna will focus on technologies for industrial automation, new materials, nanotechnologies, multimedia telecommunications and life sciences. Meanwhile, in Modena and Reggio Emilia, the Technopoles will concentrate on ceramic technology, in Parma on industrial food technology and in Piacenza on technologies for machine tools and energy. In Ferrara, the centre will focus on pharmaceuticals, environmental technologies and biotechnologies. Between Ravenna, Forlì and Rimini a strong nautical district will be developed, and in Cesena the focus will be on ICT and technologies for the manufacturing industry. Programming period 2007-2013. Total Investment EUR 241 million. See:
http://ec.europa.eu/regional_policy/en/projects/italy/developing-technopoles-as-hubs-of-innovation

The Nanofabrication Facility located in the VEGA science park (Italy): one of the first European laboratories applying nanotechnology to industrial production. Innovative techniques for treating leather and natural fabrics, anti-reflective 'moth-eye' surfaces and cold spray technical coatings are all examples of areas in which nanotechnology is able to make a difference. The facility has helped to

turn around the once crisis-stricken Veneto region in the north east of Italy by transferring technological knowledge and industrial research results to local companies. This has helped the local economy to make a major move towards knowledge-based production. Programming period 2007-2013. EU Investment: EUR 4.6 million.
See: http://ec.europa.eu/regional_policy/en/projects/italy/making-nanotechnology-work-for-industry

Utrecht Science Park (**Netherlands**): The Utrecht Science Park turned the former university campus into an employment engine for Utrecht and the surrounding area. Recognised as a key business location for knowledge-intensive companies, the Science Park is now part of a nationwide network of campuses, raising the profile of the Netherlands as a knowledge economy. The project has also resulted in the Utrecht Science Park Foundation, fully funded by the knowledge institutes and companies located on the site. The Utrecht Science Park (USP) hosts two science clusters focused on life sciences, with an emphasis on public health, cancer and regenerative medicine, and on sustainability, with an emphasis on smart sustainable cities and a bio-based economy. Programming period 2007-2013. Total Investment: EUR 2.2 million. See: http://ec.europa.eu/regional_policy/en/projects/netherlands/transforming-utrecht-science-park-into-a-dynamic-economic-engine-for-west-netherlands

Science and Technology Park of the University of Porto (**Portugal**): Promoting and validating business-oriented projects based on technology — chiefly generated by the knowledge and skills within the University of Porto. It welcomed a group of companies and innovation centres working in areas such as energy, energy efficiency, polymers and composite materials, IT and communications, and robotics. Programming period 2007-2013. Total Investment: EUR 22 million. See: http://ec.europa.eu/regional_policy/en/projects/portugal/a-catalyst-for-structural-change-in-northern-portugal

Environmental Hydraulics Institute and Cantabria Coastal and Ocean Basin Research and Development Facility (**Spain**): A new indoor wave, current and wind simulator is enabling a marine research centre in Cantabria to expand its work in coastal and offshore engineering. Programming period 2007-2013. Total Investment: EUR 31 million. See: http://ec.europa.eu/regional_policy/en/projects/spain/unique-research-centre-for-marine-engineers

Centre for the Investigation of Advanced Systems based on Information and Communication Technologies (CISA-TIC) at Catalonia Polytechnic University (UPC) (**Spain**): The project forms part of the K2M (Knowledge To Market) initiative, which is committed to the transfer of knowledge from universities to society. Programming period 2007-2013. Total Investment EUR 4.8 million. See: http://ec.europa.eu/regional_policy/en/projects/spain/centre-for-the-investigation-of-advanced-systems-based-on-information-and-communication-technologies-ict-k2m-building-at-catalonia-polytechnic-university-upc

Testlab II (**Sweden**): A project that provides an independent IT testing laboratory space and facilities within a cluster organisation. As a cluster organisation, it has focused on creating meeting places and fostering cooperation between the member companies. It was from these original cluster operations that an innovative independent testing laboratory for IT solutions was developed, offering companies the opportunity to carry out testing, ensure quality assurance and obtain software and system certification for their IT infrastructures. Programming period 2007-2013. Total Investment: EUR 1.6 million. See: http://ec.europa.eu/regional_policy/en/projects/sweden/independent-it-test-lab-a-magnet-for-success

The Environment Technology Centre (ETC), Nottingham (**UK**): has been delivering concrete solutions and tools to businesses, including free tailor-made energy assessments and guides on pollution control, to help them reduce their environmental impact and also increase profitability. Programming period 2007-2013. EU Investment: EUR 4.7 million.
See: http://ec.europa.eu/regional_policy/en/projects/united-kingdom/technology-takes-up-the-green-challenge-in-nottingham

One-stop '3D printing' shop, Tampere (**Finland**): A network of research and educational institutions, from vocational schools to universities, offers tools and expert support in 3D printing to researchers, students and local SMEs, prompting innovations and new business opportunities in the

region. Programming period 2014-2020. Total Investment: EUR 2.3 million.
See: http://ec.europa.eu/regional_policy/en/projects/finland/unique-partnership-for-3d-printing-in-tampere-finland

The Brandenburg Innovation Centre for Modern Industry (IMI) (**Germany**): IMI provides local businesses with information on the transition towards Industry 4.0. The Centre operates a model factory with demonstrators of key technologies that are shaping the new manufacturing environment. Services include workshops and round-table discussions to analyse the modernisation needs and innovation potential of individual SMEs, support the implementation of these businesses' projects, as well as information activities. Case studies detailing concrete applications developed for SMEs in the area are also available. Programming period 2014-2020. Total Investment EUR 1.9 million. See: http://ec.europa.eu/regional_policy/en/projects/germany/industry-4-0-sets-up-shop-in-brandenburg

Examples Digital Innovation of Hubs that received ERDF support:

Centre for Advanced Manufacturing Technologies, Wroclaw University of Science and Technology () http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1046/view Poland

Minalogic (Grenoble, FR) http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1297/view

FranceViaMéca (Clermont-Ferrand, France) http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1172/view

Ventspils High Technology Park (VHTP) (LV) http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1293/view